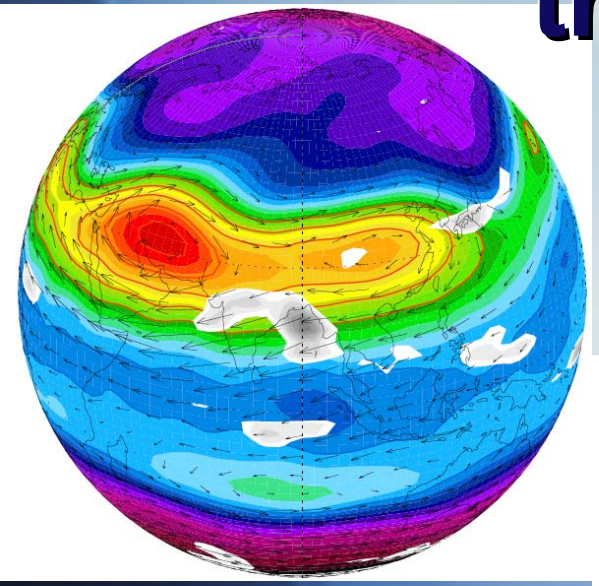
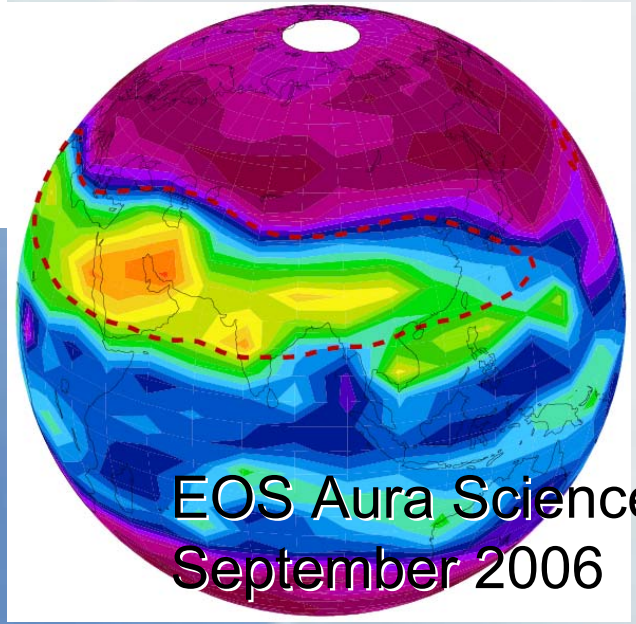
Transport above the Asian summer monsoon anticyclone inferred from Aura MLS tracers



Mijeong Park, William J. Randel, Andrew Gettelman and Steven T. Massie



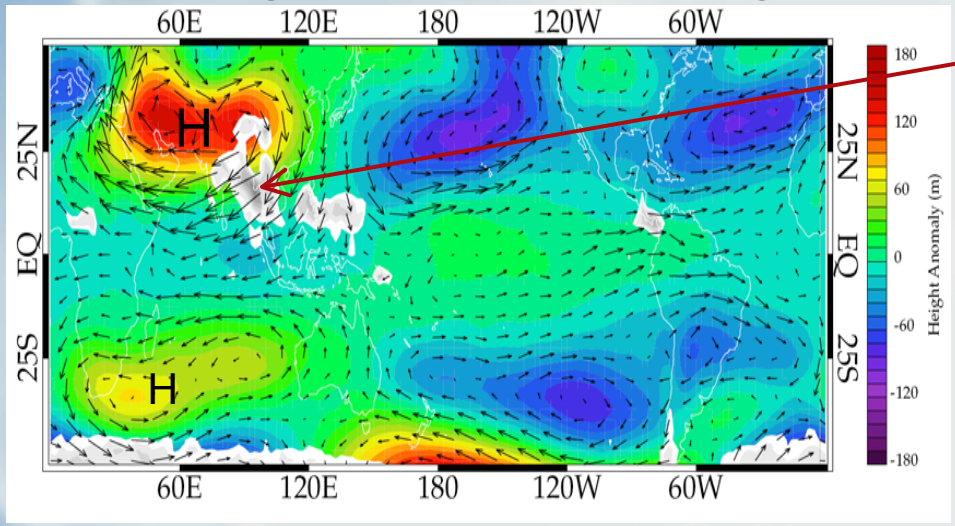
National Center for Atmospheric Research

EOS Aura Science Team meeting, 11-15 September 2006

What is the monsoon anticyclone??

NCEP geopotential height

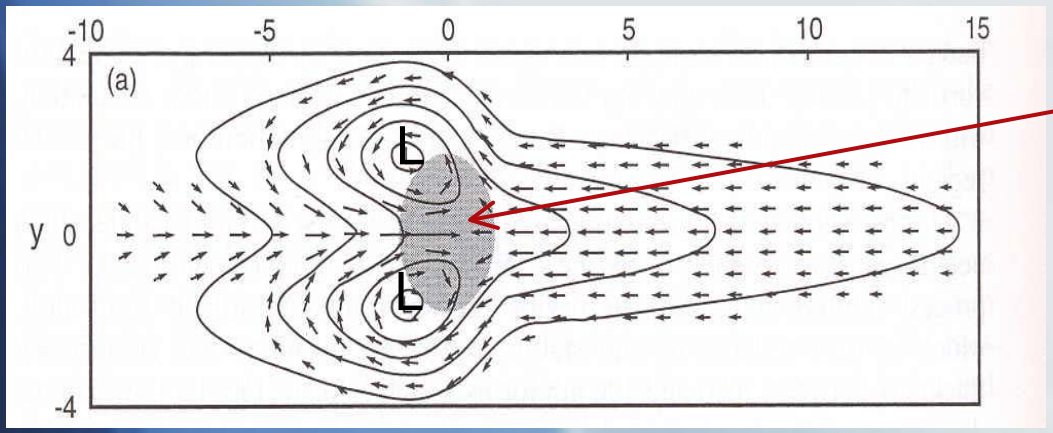
upper



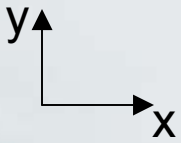
convective heat source

'Gill-type' solution (Gill, 1980)

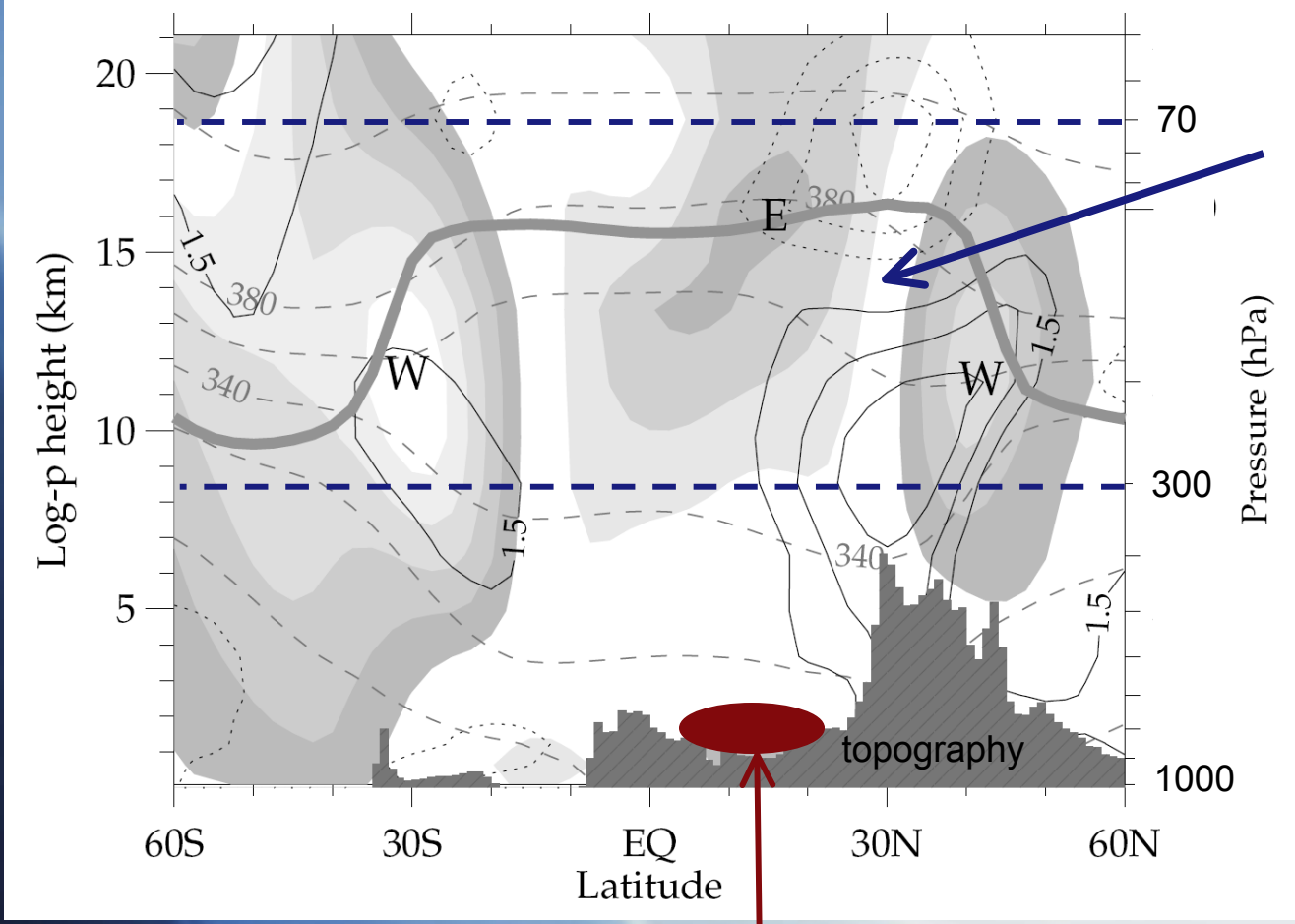
lower



imposed heat source



vertical structure of the anticyclone



anticyclone

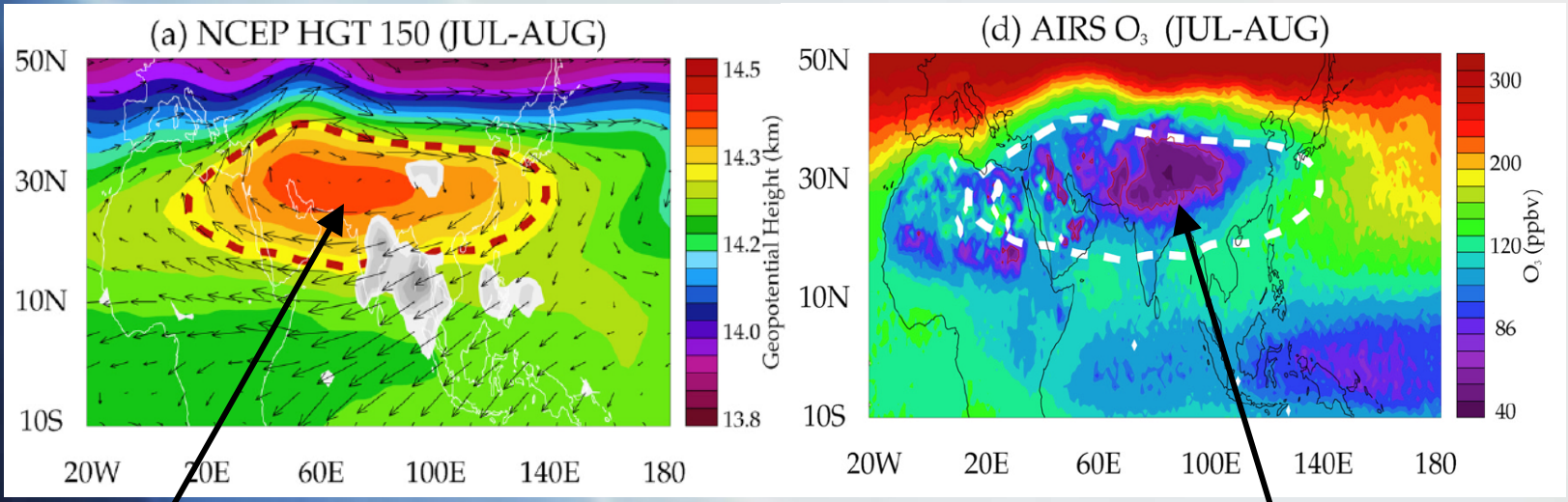
convection

alt

lat

Chemical Tracers?

- Tracers in the UTLS region show strong confinement within the Asian summer monsoon anticyclone during NH summer (Randel and Park, 2006)



monsoon anticyclone

AIRS Ozone

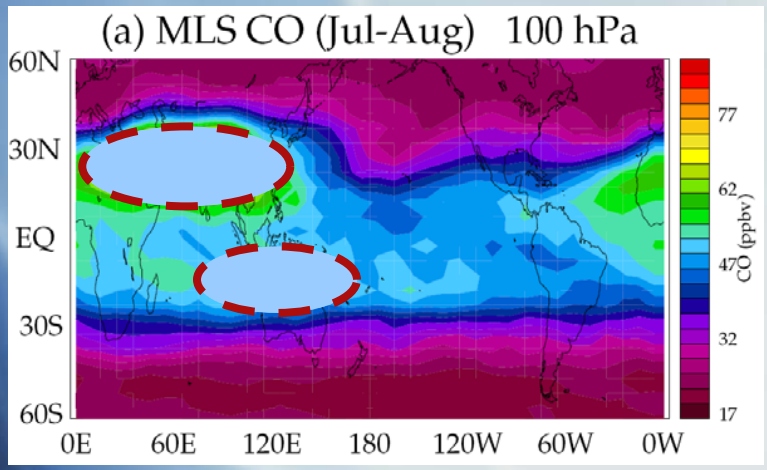
Q. Transport above the Asian summer monsoon anticyclone

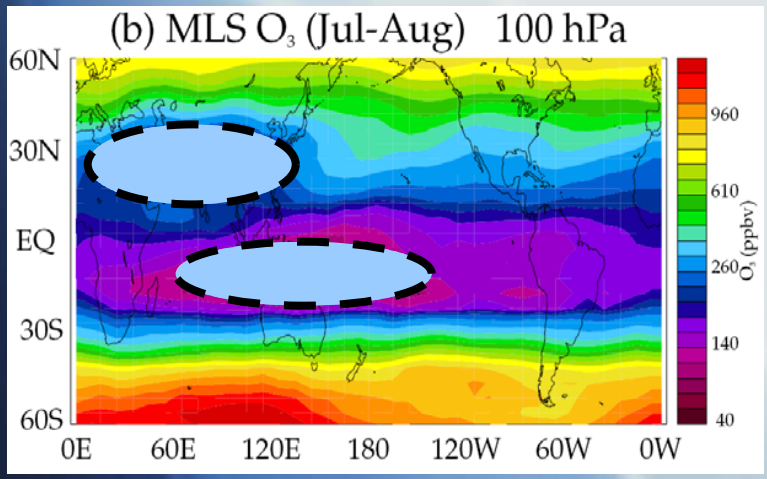
- ✓ Tracers - MLS CO, O_3 and H_2O in the UTLS region (~100-68 hPa, Jun-Aug, 2005)
- ✓ Dynamics - NCAR CAM3 and ERA40 reanalysis
- ✓ Transport - 3-D trajectory model (Bowman, 1993)

1. Climatology of Tracers

CO

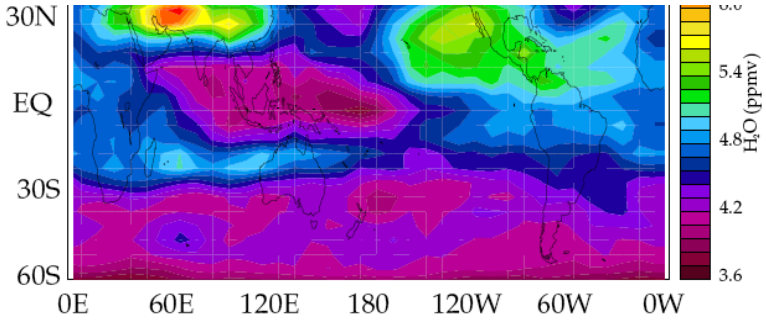
O_3

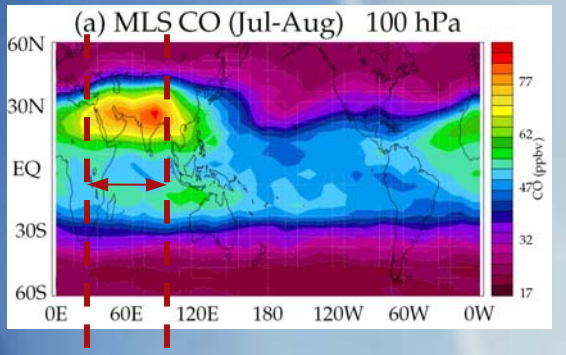




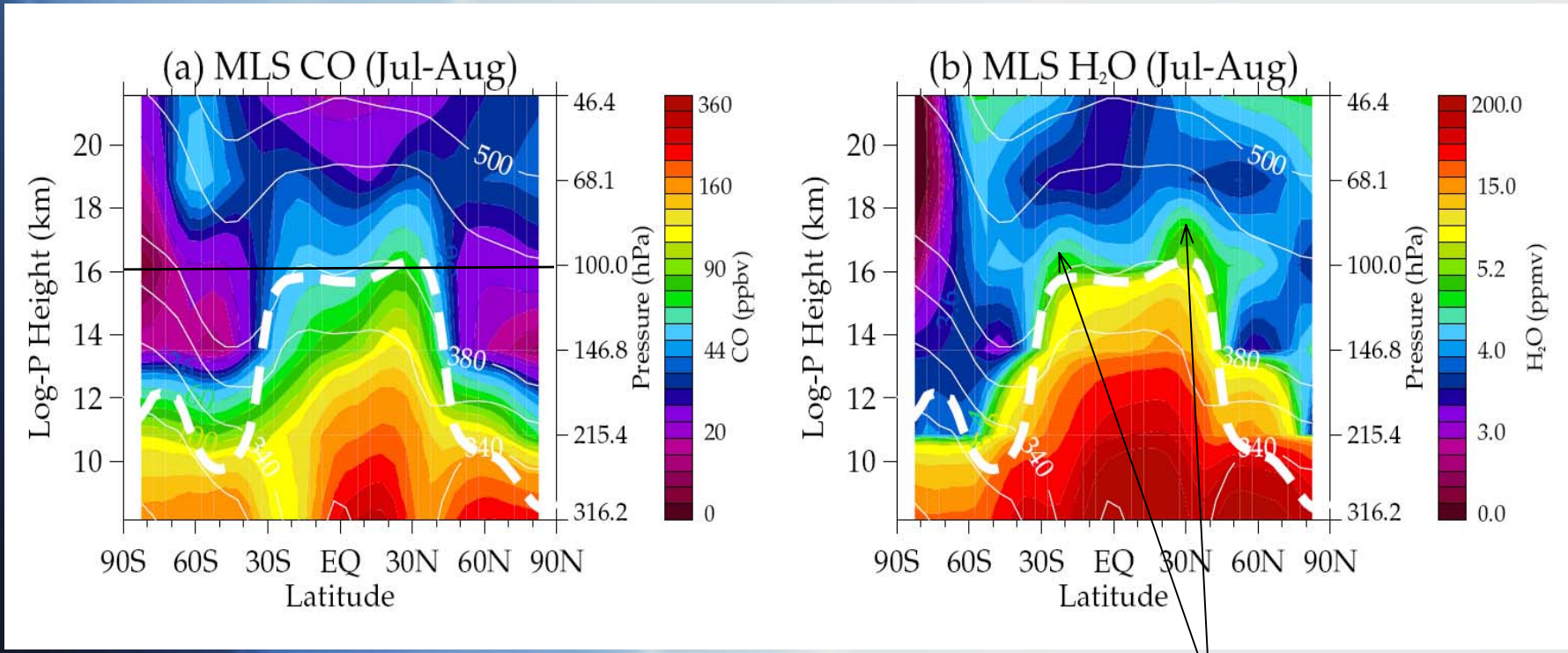
CO max & O_3 min over the Asian monsoon region and SH subtropics

H_2O max over monsoon regions



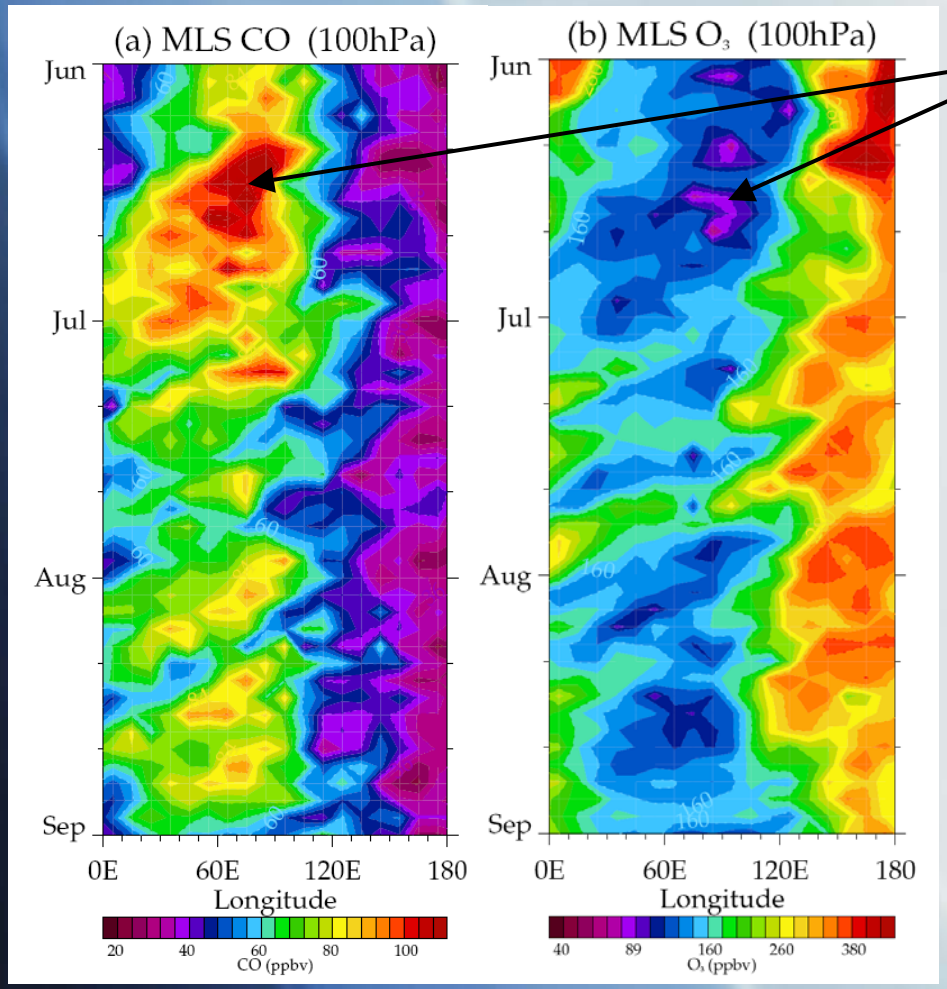


CO and H_2O - vertical sections



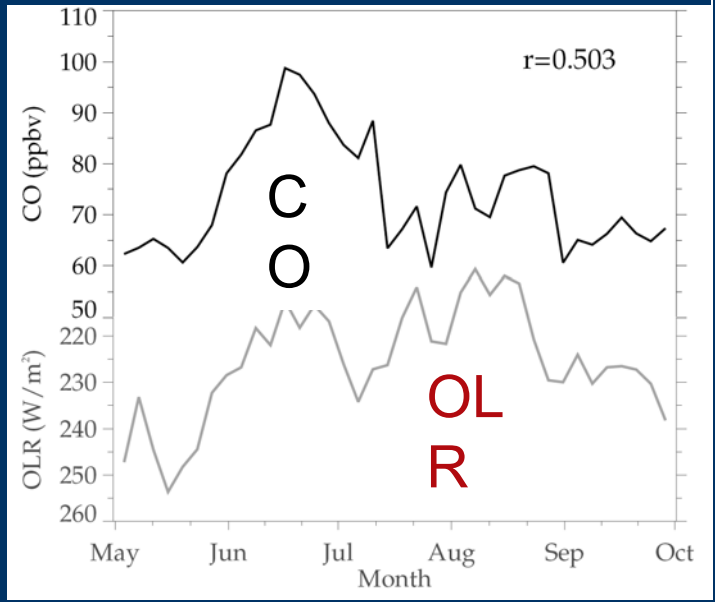
'double-peak' structure

2. Synoptic variability and convection

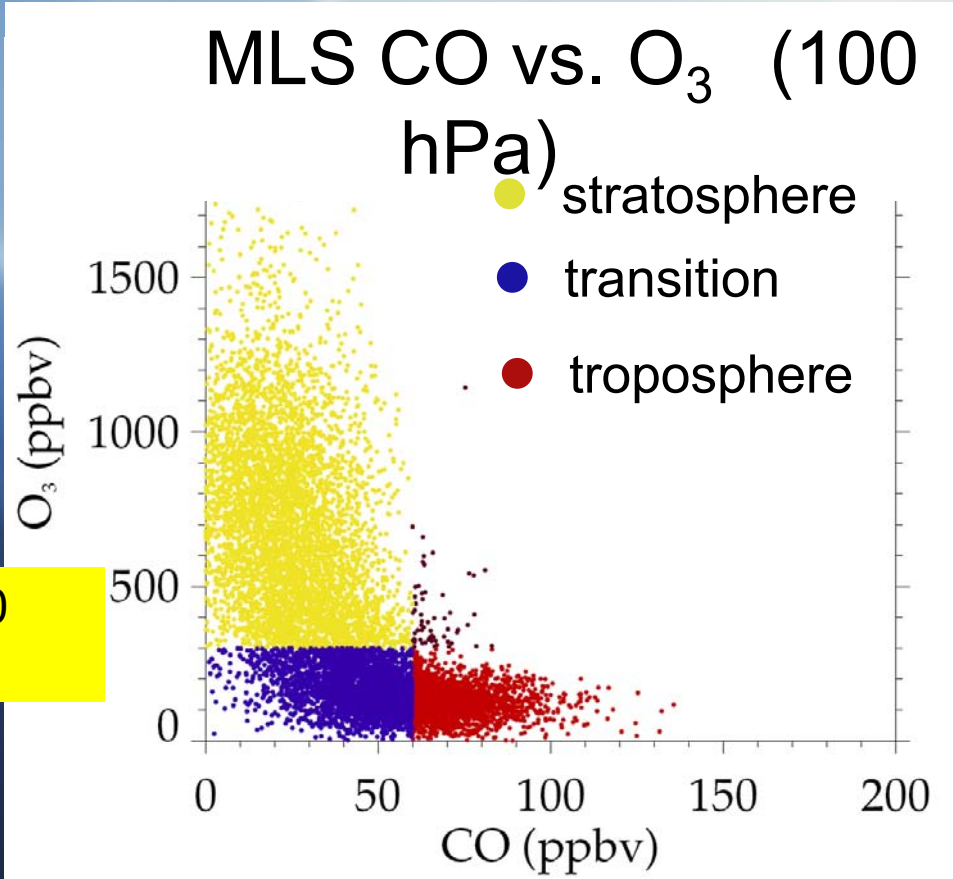


CO max & O_3 min

CO vs. Convection?

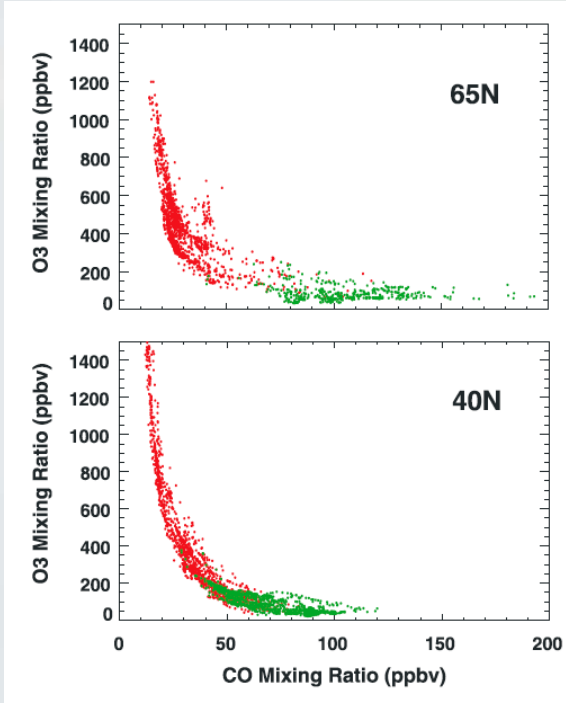


CO-O_3 correlation - quantify transition layer



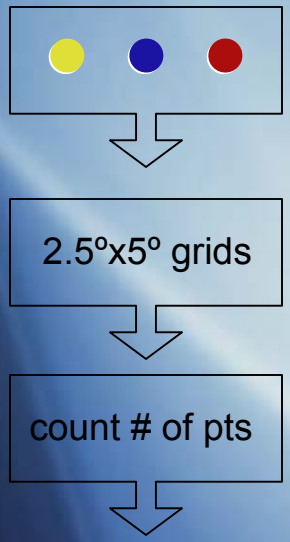
$O_3 \geq 300$ ppbv

60 ppbv ≤ CO

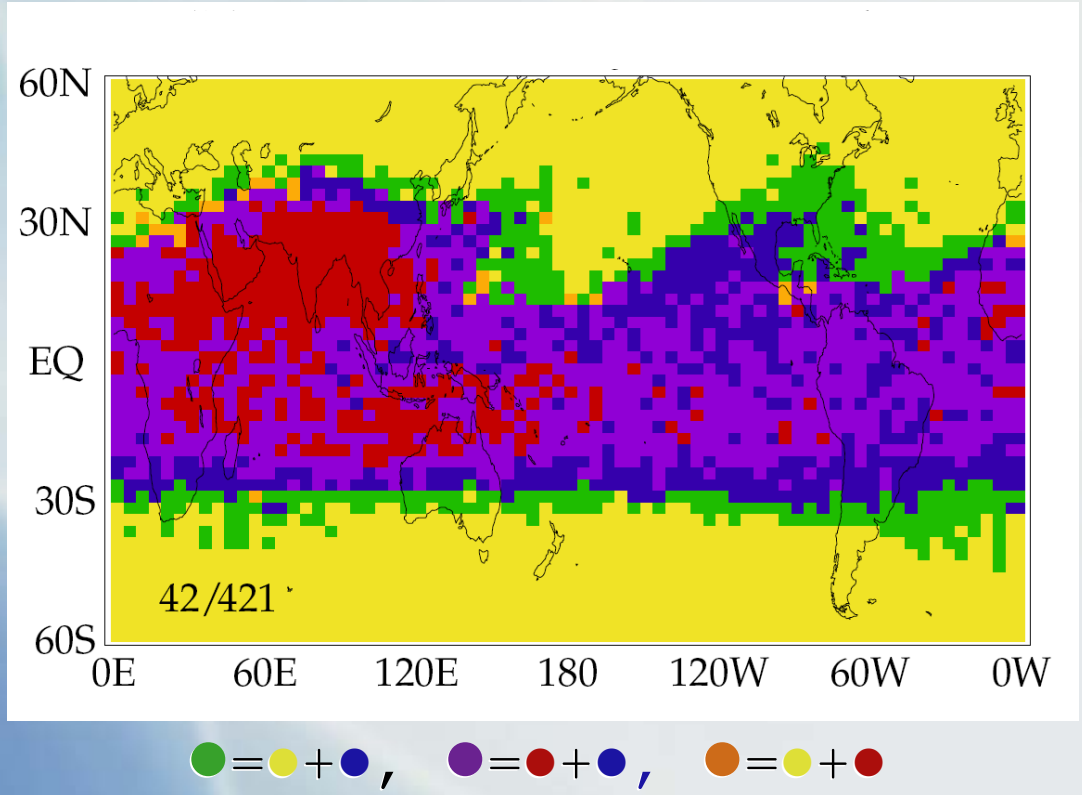


Pan et al. (2004)

statistical properties of the transition layer (June, 2005)



mixed colors determined by 2 largest numbers (transition layer)



3. Vertical transport in the monsoon anticyclone

Q. **How those tracers reach high altitude (> 16 km)?**

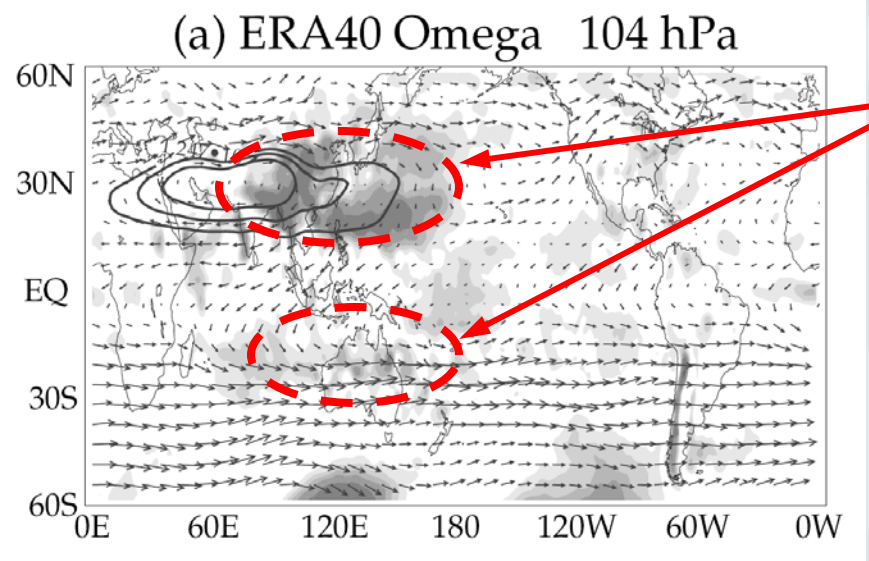
level of convective outflow is near ~ 12 km

vertical velocity?

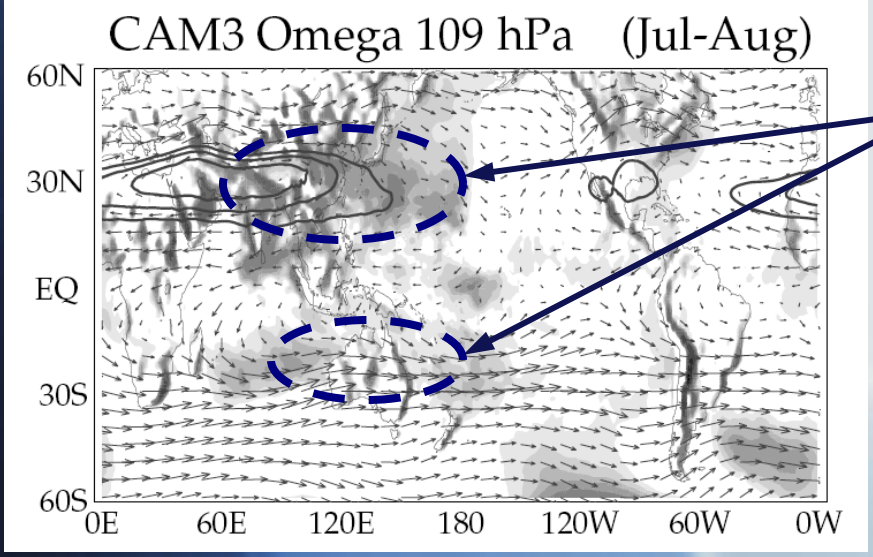
substantial uncertainties - small magnitude & no direct measurement in the UTLS region

- ✓ ERA40 reanalysis wind fields (2000-2002)
- ✓ Free-running climate model result (NCAR CAM3)
- ✓ 3-D trajectory model

ERA40 reanalysis (JUL-AUG, 2000-2002)



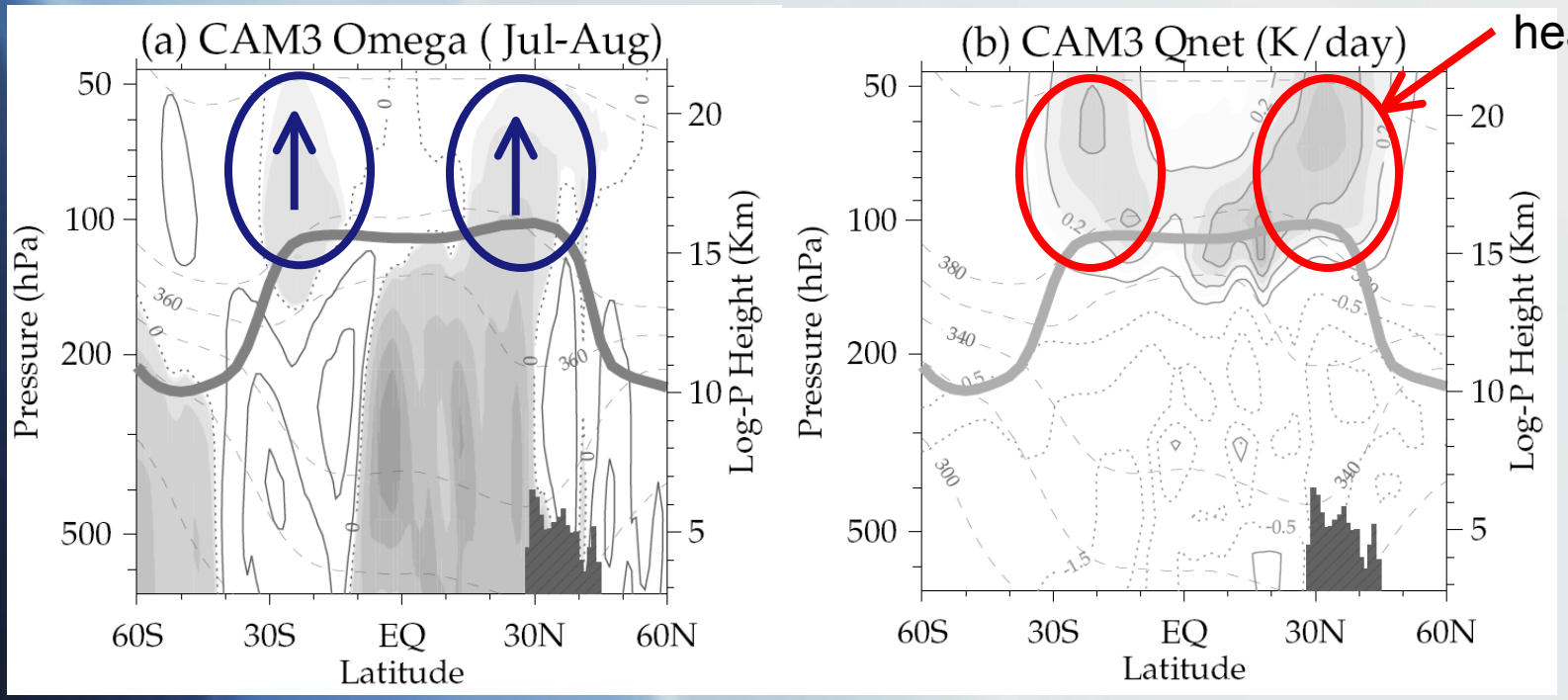
upward motions over the eastern flank of the anticyclone & SH subtropics



CAM3 vertical velocity is similar to the ERA40

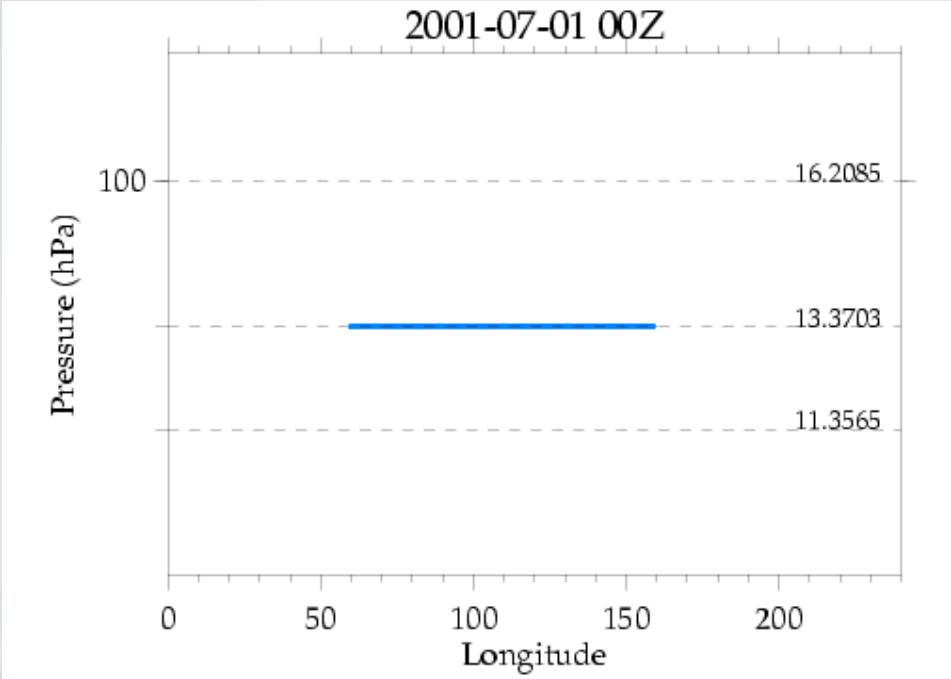
Vertical velocity & radiative heating rate

positive radiative heating in the regions of upward motion (associated cooling & convective heating below)



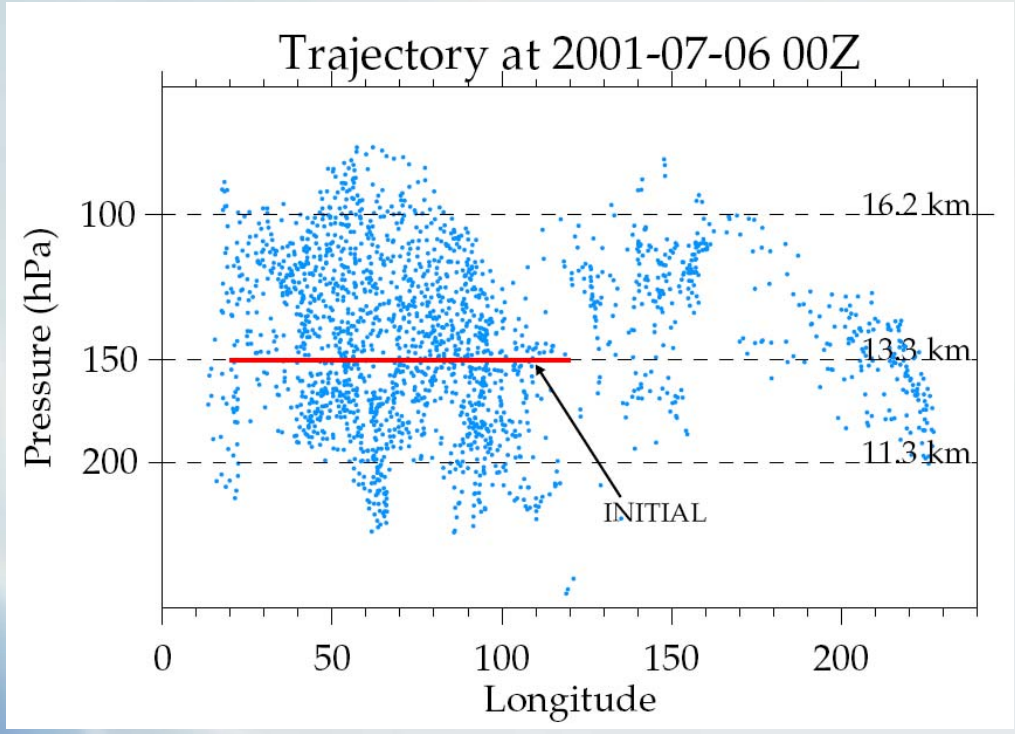
3-D trajectory calculations

- Bowman (1993)
- Input : ERA40 4xdaily (2.5ºx2.5º resolution, 23 pressure levels)
- Initialized in 20º-120º longitude/20º-40Nº latitude (2000 particles) at 150 hPa
- Starts 2001-07-01 00Z



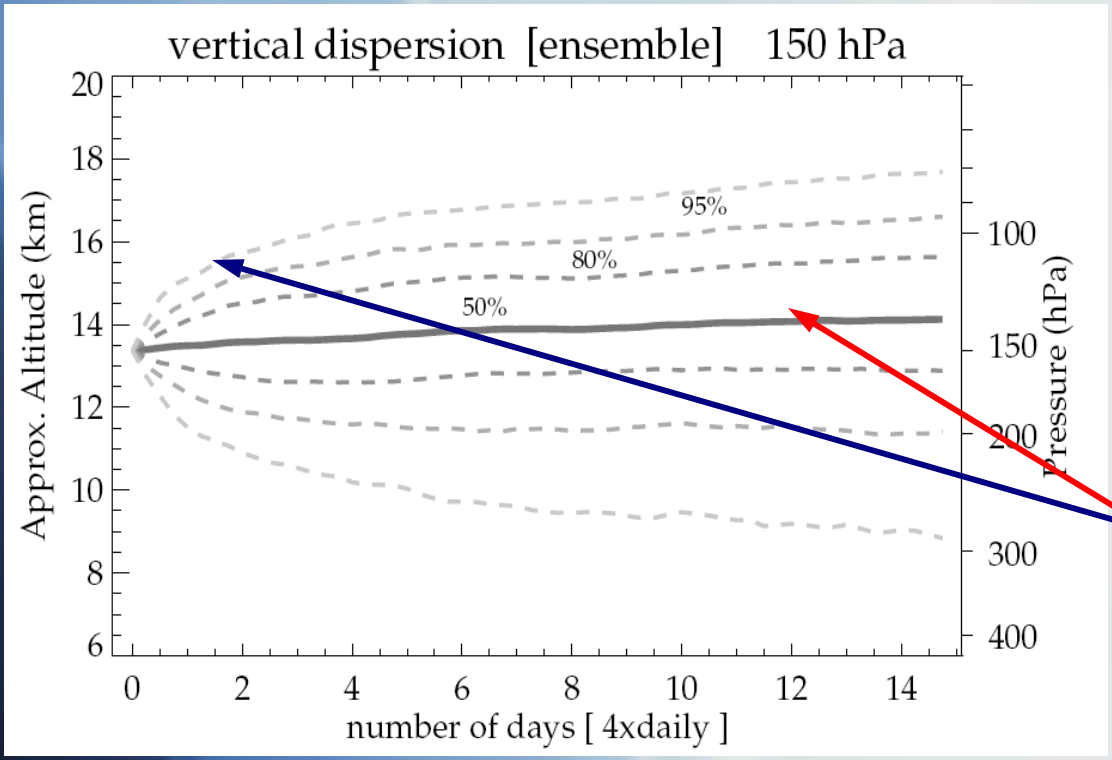
trajectory snapshot

rapid vertical spreading of particles after only a few days



majority of particles remain inside the anticyclone

Ensemble average of vertical dispersion

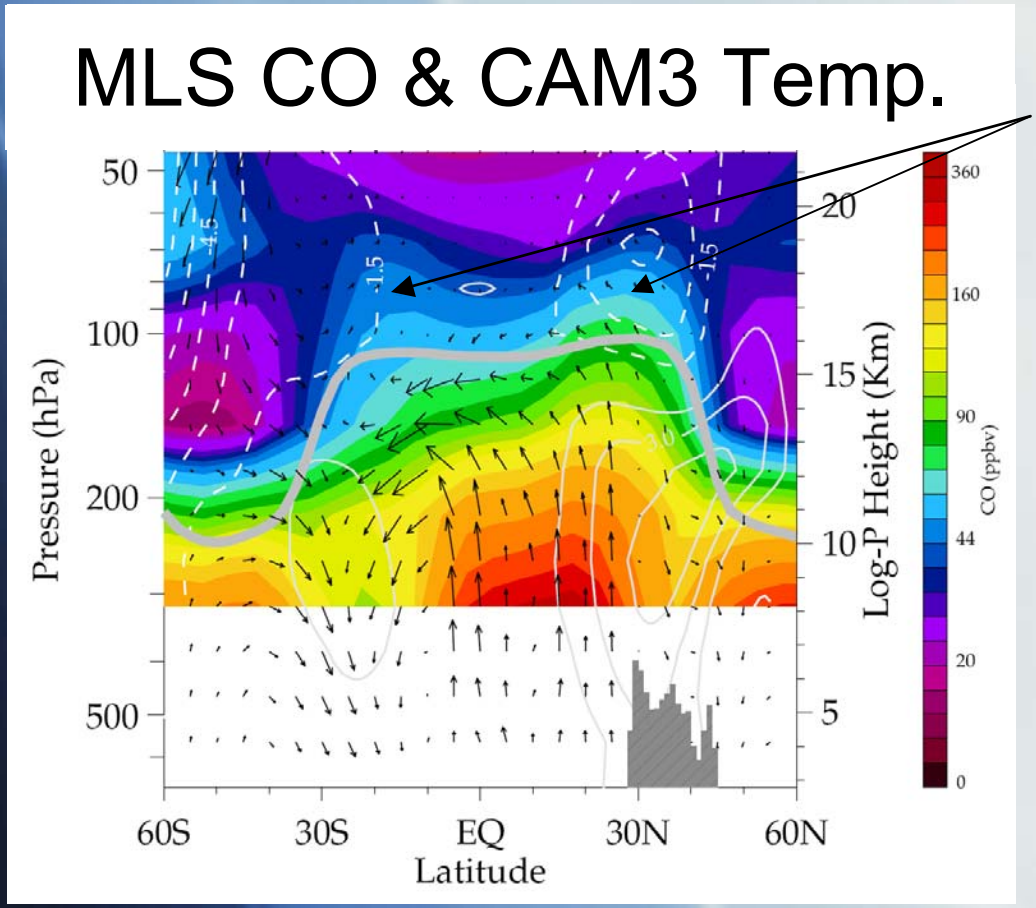


6 runs (14days, 5day apart)

1. 07/01-07/15
2. 07/06-07/20
3. 07/11-07/25
4. 07/16-07/30
5. 07/21-08/04
6. 07/26-08/09

rapid vertical spreading & ensemble average rises slowly

Circulation + Tracer + Temperature?



- 'double-peak' structure is consistent with weak upward motions

- Troposphere - upward (sinking) motion corresponding to high (low) CO in NH (SH)

Transport above the Asian monsoon region…

- ✓ Persistent maxima and minima in MLS tracers
- ✓ Synoptic tracer (& temperature) variabilities are tied to the deep convection
- ✓ Atmospheric response to the deep convection is all in dynamic balance as a ‘Gill-type’ solution
- ✓ 3-D trajectory calculation confirms the large-scale circulation transports air to the near-tropopause level
- ✓ Upward circulation possibly explain tracer anomalies extend into the lower stratosphere